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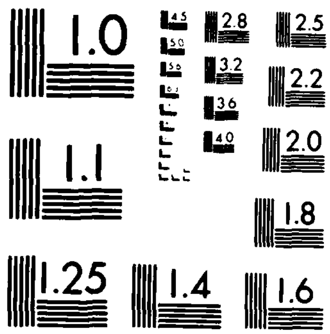
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The specific details of the results of our research work have been reported in the publication listed previously and in the six semi-annual progress reports. We wish to describe briefly here our problem and our most important results. This investigation of acoustic and ultrasonic scattering has examined both direct scattering and the much more difficult inverse scattering problem.

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a) H. Überall, A. Nagl, P. P. Delsanto, J. D. Alemar and E. Rosario: Surface Waves in Obliquely-Incident Wave Scattering from a Cylinder, Bull. A.P.S. 27, 558 (1982).

b) H. Überall et.al.: Resonance Scattering Methods for NDT, Proc. Workshop on RD for New Procedures for NDT, Saarbrücken, August 30 (1982), pag. 253.

c) A. Nagl, H. Überall, P. P. Delsanto, J. D. Alemar and E. Rosario: Refraction Effects in the Generation of Helical Surface Waves on a Cylindrical Obstacle, J. Wave Motion 5, 235 (1983).

d) H. Überall et.al.: Electromagnetic and Acoustic Resonance Scattering Theory, J. Wave Motion 5, 307 (1983).

e) P. P. Delsanto et.al.: Elastic Wave Scattering from Cylindrical Cavities and Solid Inclusions Analyzed by the Resonance Method, Proc. First Army Conf. on Applied Mathematics and Computing, Washington, D.C., 9-11 May, 1983, ARO Report 84-1, p. 773.

f) P. P. Delsanto et.al.: Resonances and Surface Waves in Elastic Wave Scattering from Cavities and Inclusions, in D.O. Thompson and D. E. Chimenti eds.: Review of Progress in Quantitative NDE, Plenum Publ., Vol. 3A, p. 111, 1984.

g) P. P. Delsanto et.al.: Resonance Scattering of Acoustic Waves from Air-Filled Cylinders in Water, J. Acoust. Soc. Am. 75, S53 (1984).

h) P. P. Delsanto et.al.: Resonance Scattering of Acoustic Waves from a Fluid Cylinder in a Less Dense Medium, Bull. A.P.S. 29, 751 (1984).

i) P. P. Delsanto et.al.: Resonance Scattering of Elastic Waves from a Fluid-Filled Cylindrical Cavity in Al and Other Metals, presented at the II Army Conference on Applied Mathematics and Computing, Troy, N.Y., May 22-24, 1984.

j) Y. J. Stoyanov et.al.: Surface Wave Modes on Spherical Cavities Excited by Incident Ultrasound, submitted for publications in the Proc. Conf. "Review on Progress in Quantitative NDE", La Jolla, Ca., Jul. 8-13, 1984.

k) P. P. Delsanto et.al.: A Numerical Approach to the Solution of the Acoustic Inverse Scattering Problem, presented at the Minneapolis Meeting of the Acoust. Soc. of Am., Oct. 9-12, 1984.

l) J. D. Alemar, P. P. Delsanto et.al.: Spectral Analysis of the Scattering of Acoustic Waves from a Fluid-Filled Cylinder I: Denser Fluid Loading, submitted to J. Acoust. Soc. Am.

m) J. D. Alemar, P. P. Delsanto et.al.: Spectral Analysis of the Scattering of Acoustic Waves from a Fluid-Filled Cylinder II: Denser Fluid Inside, submitted to J. Acoust. Soc. Am.

n) J. D. Alemar, P. P. Delsanto et.al.: Spectral Analysis of the Scattering of Acoustic Waves from a Fluid-Filled Cylinder III: The Solution of the Inverse Scattering Problem, submitted to the J. Acoust. Soc. Am.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT:

a) DR. P. P. DELSANTO
b) DR. E. ROSARIO
c) DR. J. D. ALEMAR
d) DR. H. ÜBERALL (CONSULTANT)
e) DR. A. NAGL (CONSULTANT)

STATEMENT OF THE PROBLEM AND SUMMARY OF RESULTS

The specific details of the results of our research work have been reported in the publication listed previously and in the six semi-annual progress reports. We wish to describe briefly here our problem and our most important results.

As in most branches of physics, in the study of acoustic and ultrasonic scattering we distinguish between a direct problem and a much more difficult inverse problem. Specifically, in our case the direct problem deals with the study of the scattering, the spectral response from obstacles (cavities or inclusions) and the characterization of the obstacle resonances. All kinds of phenomena are involved, like surface waves on the obstacle surface, reflection and refraction, dispersion, dissipation, etc.

A variety of mathematical methods can be used to study the resonance scattering, among which we feel that the partial wave analysis and the polar expansion (both in the frequency and mode complex plane) are especially useful. In order to gain a quantitative understanding of the scattering process, different obstacle shapes need to be investigated. Spheres and infinite cylinders are obvious candidates for this study, since their separable geometry simplifies their treatment considerably, but other geometries can also be investigated, e.g. using the transition (T-) matrix formalism.

While in direct scattering studies the shape of the obstacle and the nature of the filler are assumed to be known, in the inverse scattering problem they must be predicted by analyzing the scattering response to a given incident (continuous or transient) wave form. For a large variety of applications (e.g. quantitative non-destructive evaluation) even a rough numerical solution of the inverse scattering problem can be an important step forward.

Our approach to the inverse scattering problem is based on the consideration, quite familiar from atomic spectroscopy, that the spectral response contains, in principle, the complete information about the scatterer. This information is, however, hidden in an irregular and very intricate array of peaks and valleys. The resonance scattering theory, developed by one of us (H. Überall), can be an optimal tool for disentangling the spectral response structure through the separation of the internal resonances from the external resonances and/or background and their partial wave analysis.

A broad knowledge of the direct scattering process is, of course, a fundamental prerequisite and we have analyzed several scattering situations, as well as the mathematical tools for their study (see e.g. ref. 2, 3 and 4 in our list of publications during the performance period). Then we have developed the detailed formalism for the study of scattering resonances in the 4 cases of a fluid or a solid filler of a

cylindrical scatterer and a solid or fluid loading medium (ref. 5). We have used our formalism for the detailed study of acoustic resonances (ref. 12 and 13) and elastic wave resonances (ref. 9) in uniform homogeneous media.

Using the direct scattering results, we have proposed (ref. 9, 11 and 14) a step-by-step approach, which allows to predict simultaneously the size, orientation and nature of the scatterer, from the analysis of the scattering response. Specifically we have produced simple (nearly linear) graphs, from which e.g. the sound velocity of the filler can be directly read from the position of the resonances or the peak separation, and the filler density from the resonance widths. A nearly linear dependence betwen e.g. sound velocity and resonance positions had been previously found for high overtones. An important result is that we have extended these considerations to the first few resonances and made them quantitative thru our graphs. We have also identified some characteristic features of cylindrical scatterers, which we plan to use as first examples of shape related spectral characteristics.

A similar analysis has been carried on for spheres (see e.g. ref. 10). We have also worked at a T-matrix version for the treatment of non-separable geometries. We plan to use extensively this T-matrix program for the next stage of our research work, in which we wish to develop an effective shape discrimination scheme, to complete the numerical solution of the inverse scattering problem.

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